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## Abstract

The use of lifelogging device in dietary assessments can reduce misreporting and underreporting, which are common in the previous studies conventional methods. We performed the first study in Chinese children (primary school Grade 4) that applied the wearable cameras in assisting dietary recall. Children (n=52) wore the wearable cameras (Narrative Clip 2) for seven consecutive days, during which they completed a 3-day 24-hour dietary recall at home. Then children modified their dietary recalls at school by reviewing the photos taken by the wearable camera at school, with the assistance of the investigator, and generated the camera-assisted 24-hour dietary recalls. Compared with camera-assisted dietary recalls, 8% (n=160) and 1% (n=11) of food items were underreported (*i.e.* not reported at all) and misreported (*i.e.* reported in an incorrect amount) by dietary recalls without camera-assistance, respectively. Dietary recalls without camera assistance underestimated daily energy intake by 149±182kcal/d (8%) in comparison to the camera-assisted dietary recalls. Foods consumed on the snacking occasions (40%) were more likely to be underreported than those consumed at main meals ($P$<0.001). Beverages (37%), fruits (30%), snacks and desserts (16%) were foods most likely to be inaccurately reported. Children were satisfied with the wearable cameras, with a median score 5.0 (IQR: 5.0-5.0) for most features. Wearable cameras hold promise for improving accuracy of dietary intake assessment in children, providing rich objective information on dietary behaviours, and received high level of satisfaction and compliance of the users. Our results suggest that the accuracy of dietary recall among Chinse school-aged children could

25 be improved by wearable camera, especially avoiding underreporting in the snacking

26 occasions.

27 **Keywords:** wearable cameras, 24-hour dietary recall, children, obesity

# The use of wearable cameras in assessing children's dietary intake and behaviours in China

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## 1. Introduction

The prevalence of childhood overweight and obesity in China has increased dramatically from 1% and 0.1%, respectively in 1985 [1] to 12% and 9% (based on the Working Group for Obesity in China criteria) for children aged 7-18 years in 2015 [2]. As dietary intake and behaviours are major contributors to obesity and Chinese diets and eating patterns are different from those in the western countries, study on the dietary assessment methods is important in China.

Traditional self-reported dietary assessment methods have been criticized for their accuracy in determining energy intake [3]. Conducting dietary assessments is even challenging among school-aged children, because children have limited comprehension of food variety and quantity, and cooking methods, and also have difficulties in concentrating their attention to food recalls [4]. Underestimation of food intake is common in children's dietary assessment [5]. Caregivers are often required to assist their children to complete dietary assessment. Chinese school-aged children often eat together with family members at the table, which are different from those in western countries. The practice of sharing plates of food with family members could make children's dietary assessment more difficult.

Digital technologies, such as photo, video and audio, have been used in dietary assessment to enhance accuracy and ease of administration by ensuring rapid, regular and immediate recording of food intakes [6-10]. Wearable cameras are one of the photo-assisted methods that have been employed. The wearable camera could also capture the mealtime interaction between family members, and help to differentiate which foods are eaten by the participant and which foods are eaten by others. Most

dietary surveys applying the wearable cameras were among individuals aged above 16 years and these studies have taken place in western countries [11-16]. Its use among school-aged children has only been reported in five studies in the UK [17], US [18] and New Zealand [19-21] with relatively small sample sizes.

It is hypothesized that the use of wearable cameras would enhance the accuracy of the dietary assessment among Chinese school-aged children. The aims of this study were i) to evaluate the validity of the 24-hour dietary recalls by comparing results obtained from surveys with and without the assistance of photos; and ii) to evaluate the feasibility of the wearable cameras on children's dietary assessment by analyzing the satisfaction questions from the children's questionnaire.

## 2. Materials and Methods

### 2.1.The participants

This study was conducted in a primary school located in a Beijing suburb from May to October 2017. The school supplied lunch to students daily. The school was not a boarding school, not specific to ethnic minority students or students of particular skills. The school had not participated in any childhood obesity interventions during the past year.

Children at Grade 4 (typical age range 9 to 10.9 years) of the selected primary school were our potential participants. Exclusion criteria were a history of severe heart, lung, liver, or kidney diseases (*e.g.* hypertension, tuberculosis); iatrogenic obesity; abnormal growth (*e.g*. dwarfism, gigantism); a physical disability; or attempts to lose weight (*e.g.* on diet, taking weight reduction medications) during the past three

months. Written informed consent was obtained from the children and their parents. This study was approved by the Institutional Review Board (IRB) of Peking University Health Science Centre.

## 2.2.Data collection

### *2.2.1. Children's data from physical examination and school record*

Physical examinations of weight (kg) and height (m) of each study participant were conducted by the investigator who had been trained to undertake physical measurements. Information on children's sex and date of birth were obtained from the school's registration records.

### *2.2.2. Training in study procedures*

A training session was given by the investigator to the children and their primary caregivers. A brief questionnaire was delivered to the caregivers one day before the training session. Caregivers were required to report their education, occupation, their height and weight, and returned the questionnaire when they came to attend the training.

In the training session, the purpose and procedure of the study were explained to the children and caregivers. The children were informed that they should wear the camera for seven days during the study period. The caregivers were taught how to help their children to wear the cameras, how to select two weekdays and one weekend day among the study week to complete the 24-hour dietary recall, and how to use the electronic kitchen scales to weigh foods if they had problems in estimating food weight. Children were allowed to wear and familiarize themselves with the camera for

a day prior to the study.

The ethical framework for automated wearable cameras developed by Kelly *et al*. [22] was adopted in the development of ethical protocol of this study. Specifically, in the training session, children and their caregivers were notified the approximate number of photos to be taken, messages to be collected, and potentially private events that could be photographed *(e.g.* private family moments, use of bathrooms) by the wearable cameras. Children and their caregivers were informed of their rights to delete any photos if they wished to do so, before the investigator reviewed and analyzed the photos. Children were notified that they should shut down the camera when entering photo-restricted venues (*e.g.* swimming pools and changing rooms).

#### *2.2.3. The use of the wearable cameras*

During the study, children wore the camera for a week. The children fixed the wearable cameras (Narrative Clip 2, made in Taiwan, designed in Sweden) on their collar with a metal clip and elastic lanyard after they woke up, and removed it before they slept. Since the camera's maximal battery life is six hours, children were given two cameras and changed camera twice per day, when they arrived at school in the morning and when they left school in the afternoon. Once the cameras were removed for charging, photos stored were exported to a computer. The investigator screened all photos taken, and deleted the ones irrelevant to diet. From the remaining photos, the investigator selected the ones to represent all foods consumed in all meals each day per child. The photos selected should clearly show foods in front of the child. In most circumstance, each eating occasion (*e.g*. breakfast, lunch, dinner, snacking) was represented by one to two key photos. Therefore, six to eight key photos representing

all foods consumed each day were used in the camera-assisted dietary survey in the next day.

#### *2.2.4. Dietary recalls without camera assistance*

Children completed a 3-day 24-hour dietary recall during the study week. They were allowed to choose any two weekdays and one weekend day, during which children recorded all the foods and beverages they had eaten from the morning when they woke up to the nighttime before they slept, with the assistance of their primary caregivers. Electronic kitchen scale that provided by the investigator could be used to weigh foods if children had problems in estimating food weight.

The next day at school, the investigator collected the dietary records, and assisted each child to check and modify his/her record. The food atlas [23] developed by the Institute of Nutrition of the Chinese Center for Disease Control and Prevention was used to help the children estimate the quantity (weight [g] or volume [ml]) of foods they had eaten. Initially, the child was asked to check each food item recorded, and required to modify the record if incorrect reporting existed. Dietary recall without camera assistance was generated.

#### *2.2.5. Camera-assisted dietary recalls*

After confirming the dietary recalls without camera assistance, the investigator showed the pre-selected eating event photos (n=6-8, detailed above) to the child in time sequent, and asked the child to check each food item recorded and to modify or confirm his/her record. The dietary recall generated upon viewing photos was called camera-assisted dietary recall. At the end of the study, a self-administered

questionnaire was distributed to the children, to examine their satisfaction with the wearable cameras.

For both the dietary recalls data with and without camera assistance, the daily dietary intakes (including energy, macronutrients, and micronutrients) were calculated using the China Food Composition Tables [24, 25] and the Dietary Reference Intakes of the Chinese Residents [26].

### *2.2.6. Photo annotation*

Upon the completion of the fieldwork, photos were stored by the investigator in a password-protected computer. The protocol (see Supplementary document 1) for photo annotation was developed by the investigator after an intensive review of the relevant literature [11, 16, 17]. Briefly, for each child per day, the investigator screened all photos taken in order, and identified photos related to dietary, physical activity, purchasing or screen time events. Photos related to dietary events were reviewed carefully and coded into eating occasions (including breakfast, lunch, dinner, and snacking) and dining locations (including home, school, restaurant, others, such as on the move to somewhere). For each eating occasion, information on the starting and ending time of the meal, dinning location, whether the child watched electric screen while eating, and whether the child ate and was accompanied by others was obtained according to the photos and documented in a table. Dietary events captured by photos showing at least one switched-on electric device (*e.g.* TVs, computers, tables and mobile phones) were indicated as ‘eating events involving screening behaviours’. Similarly, dietary events captured by photos showing at least one other person together with the child (*e.g.* parent, grandparent, sibling, friend) were indicated

as ‘eating with family members or friends’. It took approximately 40 minutes to code one-day of photos for one child. For quality assurance, photos that recorded all dietary events of five randomly selected children (*i.e.* 10% of the total participants) were re-coded. Consistency of the coding between the first and second time should not be less than 80%.

**2.3.Measures**

***2.3.1. Measures on children’s characteristics***

Children’s age was calculated from their date of birth. *Children’s Body Mass Index (BMI)* was calculated from the physical examination results. Children were classified into wasting (aged 9.0-9.9 years, male: BMI<14.1, female: BMI <13.8; aged 10.0-10.9 years, male: BMI <14.4, female: BMI <14.0), healthy weight (aged 9.0-9.9 years, male: BMI=14.1-18.8, female: BMI=13.8-18.9; aged 10.0-10.9 years, male: BMI=14.4-19.5, female: BMI=14.0-19.9), overweight (aged 9.0-9.9 years, male: BMI=18.9-21.3, female: BMI=19.0-20.9; aged 10.0-10.9 years, male: BMI=19.6-22.4, female: BMI=20.0-22.0), and obese (aged 9.0-9.9 years, male: BMI≥21.4, female: BMI≥21.0; aged 10.0-10.9 years, male: BMI≥22.5, female: BMI≥22.1) categories according to the BMI classification criteria for school-aged children and adolescents in China [27, 28]. The Chinese criteria is similar to the World Health Organization (WHO) criteria using BMI-for-age (z score), while the cut-off values are slightly different. The Chinese method classified children according to their year of age rather than month of age (the WHO method). Details of two criteria for children between 9 and 11 years (*i.e.* age range of our study participants) are provided in Supplementary document 2. *Parents’ BMIs* were also calculated according to their self-reported weight and height. *The socioeconomic status of family* was evaluated by the Green’s

score [29]. Green's score=0.5× (father's level of education score ×0.7+ father's occupation score ×0.4+ mother's level of education score ×0.7+ mother's occupation score ×0.4). The scorings for different education and occupation categories are detailed in Supplementary document 3. A higher score indicates higher social economic status of the family. The median score among the current study population (54.95) was used to classify participants into lower (⩽54.95) or upper (>54.95) socioeconomic status.

#### *2.3.2. Measures on the accuracy of dietary recalls*

Food items collected from the dietary recalls without camera assistance were compared against those in the camera-assisted dietary recalls, and classified into correctly, underreported (*i.e.* not reported at all), and misreported items (*i.e.* reported in an incorrect amount). Results of the daily dietary intakes obtained from the camera-assisted 24-hour dietary recalls were compared with that from children' memory only recall.

#### *2.3.3. Extracting food measures from camera data*

The table documented information of each eating occasion per day and per child was used to analyze mealtime duration, eating rate, number of days eating outside home, in western fast food restaurants, breakfast consumption, the proportion of watching electric screen while eating, and the proportion of eating with family members or friends. *Mealtime duration* (in minutes) was calculated as the differences between two photos with the time stamp indicating the start and end of the same dining event. *Eating rate* (gram/minute) was calculated as the average grams of foods consumed at each meal (measured by camera-assisted method) divided by the average mealtime

duration for each person (minutes). *Number of days eating outside home, in western fast food restaurants*, and *consuming breakfast during the study week* were estimated according to the coding of the photos related to dietary events. *The proportion of watching electric screen while eating* (%) was calculated as the number of dietary events that involved screening behaviours divided by the total number of dietary events, and then multiplied by 100. The higher the proportion, the more frequent the screen time while dining was. *The proportion of eating with family members or friends* (%) was calculated as the number of dietary events where others were present divided by the total number of dietary events, and then multiplied by 100. The higher the proportion, the more frequently the child ate together with others.

**2.4.Sample size calculation**

Because the main purpose of this study was to assess the data accuracy of the traditional dietary recall method, sample size estimation was based on the differences of daily energy intakes measured by dietary recalls with and without camera assistance. Based on data from Gemming *et al*. [12], the effect size (Cohen's d) of the difference of daily energy intakes between recalls with and without camera assistance was set as 0.4. A total of 54 participants could achieve 80% potential power to detect such difference, using a two-sided T-test with a significance level of 0.05. Assuming a 10% of attrition or data ineligibility, a total sample size of 60 was estimated.

**2.5.Statistical analyses**

Descriptive statistics (frequencies, means and standard deviations, median and interquartile range) were used to describe the socio-demographic characteristics of the children, their dietary intakes and behaviours, and their satisfaction with the wearable

cameras. Chi-square analyses (for categorical variables) and Independent Sample T test (for continuous variables) were conducted to detect the differences in socio-demographic characteristics between healthy and obese children. Correlation coefficients (r) and Independent Sample T-test were performed to test the correlation and differences of intakes obtained by two methods (*i.e.* dietary recalls with and without camera assistance), respectively. 95% limits of agreements between two methods were also calculated using the Bland-Altman method [30]. Statistical significance for all analyses was set as a *P* value <0.05. Data analyses were performed with the SPSS 20.0 software.

## 3. Results

A total of 62 primary school students at Grade 4 were screened for eligibility based on the criteria described earlier. With a further exclusion of 10 participants who did not complete the 3-day dietary recall, 52 students were included in the study. Characteristics of the children participants were presented in Table 1. There were equal numbers of two sexes (male/female) and weight subgroups (healthy weight/obese). No children were classified as wasting or overweight according to the Chinese BMI classification criteria. Obese children were in a significantly lower social economic status, in comparison to the children with healthy weight ($\chi^2$=8.67 *P*<0.005). There were significant differences of maternal BMI (t (*df*=50) =-4.03, *P*<0.001) but not paternal BMI (t (*df*=34) =-1.23, *P*=0.229) between obese children and children of healthy weight status (Table 1).

Using the results obtained by the camera-assisted dietary recall method as reference, the food items recorded by the dietary recall without camera assistance were

267 categorized into correctly reported items (n=1869, 92%), not reported items (n=160,
268 8%) and misreported items (n=11, 1%). Foods consumed at snacking occasions were
269 more likely to be inaccurately reported than those consumed at breakfast, lunch or
270 dinner ($\chi^2$=394.60, *P*<0.001). Foods consumed in other places (*e.g.* on the move) were
271 more likely to be inaccurately reported than foods consumed in school, restaurants
272 and home ($\chi^2$=63.75, *P*<0.001). Food items that were most likely to be underreported
273 or misreported were beverages, fruits, snacks and desserts ($\chi^2$=259.06, *P*<0.001)
274 (Table 2).
275
276 Table 3 presented the daily dietary intakes (energy, macronutrients, and
277 micronutrients) obtained from dietary recalls with and without camera assistance.
278 Results from dietary recall without camera assistance were significantly lower than
279 that from recall with camera assistance (t ranged between -5.95 and -2.21, *P* ranged
280 between <0.001 and 0.015), although there were high correlations between the results
281 of two methods (r ranged between 0.69 and 0.97, *P*<0.001). The 95% limits of
282 agreement for energy, carbohydrate, protein and fat intake were -150±357, -24.2±58.0,
283 -5.9±24.5, and -3.7±12.0, respectively, when assessed using two methods (Figure 1).
284
285 A total number of 345, 918 photos were used in photo annotation. The overall
286 consistency between the first and second time coding was 94%, which met the
287 pre-specified requirement of 80%. The consistencies of coding for eating occasion,
288 eating location, eating events involving screening behaviours, and eating with family
289 members or friends were 92 %, 98%, 98%, and 93%, respectively. Dietary behaviours
290 of the children were presented in Table 5.
291

Over the study period, children spent a median duration of 13.0 hours (IQR:12.3-13.8) per day on weekdays and 10.5 hours (IQR: 9.1-11.9) per day on weekends wearing the device. The majority of the children were satisfied or very satisfied with the weight, size, appearance, comfort, and speed of battery re-charging of the wearable cameras, with a median score 5.0 (IQR: 5.0-5.0) for most features (Table 4). Most of the children (90%) gave feedback that the food-related photos were very helpful in supplementing the food recalls.

## 4. Discussion

To our knowledge, this is the first study reporting the accuracy of the use of wearable cameras in children's dietary assessments. Our results suggest that the use of wearable cameras in a 3-day dietary recall can enhance the accuracy of results by reducing underreported or misreported food items. Rich information on dietary behaviours were obtained from the photo data. Time spent on wearing the device and feedback from the children suggest high compliance and acceptability of the novel technique among the Chinese school-aged children.

Our study revealed a strong correlation between food selection and intake from dietary recalls with and without camera assistance, but results from the dietary recalls without camera assistance were significantly lower than that from the camera-assisted dietary recall method. Our results are in accordance with the studies by Gemming *et al*. [12] and Pettitt *et al*. [13], which reported that although the 24-hour dietary recall with and without the assistance of cameras had lower energy consumption results, results of camera-assisted method were closer to the references value (measured by the doubly labelled water technique), regardless of sex and weight status. Moreover,

317 our result is consistent with Gemming *et al*. [15] that the proportion of underreporting
318 was higher than that of misreporting. The main reason might be when the investigator
319 showed the photos, children could remember what they have eaten, but not how much
320 they have eaten. Our result suggests that the camera-assisted 24-hour dietary recall is
321 more advantageous in reducing underreporting than misreporting of food intakes. In
322 addition, our study relied on the children to amend and modify the 24-hour dietary
323 recall. The investigator showed children the photos; and the children confirmed foods
324 documented in the dietary recall had been consumed by themselves. Our method is
325 considered to be more accurate than that the investigator analyzing photos on his/her
326 own. This is because not all foods shown in the photos were eaten by the children,
327 and the investigator would not be able to correctly differentiate which ones had been
328 eaten by the children, which ones had been eaten by others, and which ones were not
329 eaten but moved to elsewhere. Our method is supported by Cowburn *et al*. [17] that
330 teenagers using photos taken from wearable cameras could accurately remember
331 eating and purchasing events.
332
333 Our study suggests that the self-reported data on breakfast, lunch and supper was
334 relatively accurate; while foods consumed in the snacking occasion were likely to be
335 underreported. One reason might be that children forgot to report snacks. Another
336 reason might be that children intentionally avoided reporting unhealthy snacks (such
337 as chips, ice-cream) which the children might not be allowed to consume according to
338 the usual requirement of their caregivers. Our results were consistent with the
339 literature that snacks were easily to be misreported or underreported [12, 15, 31]. Our
340 study found that foods eaten on the move to somewhere were more likely to be
341 underreported or misreported. The investigator had already emphasized the additional

342 eating occasion and eating on the move in the training session, but there were still
343 underreported or misreported foods in some cases. Our results suggest attention
344 should be paid to the reporting at snacking occasion without the companion of
345 caregivers in performing children's dietary survey. Beverage, fruits, snacks and
346 desserts were found to be the top three food items underreported in our study.
347 Gemming *et al*. [12, 15] reported that fruits and vegetables, beverage, and desserts
348 were more likely be misreported or underreported than other foods among adults. Our
349 study separated fruits and vegetables, and found that only 4.1% of vegetables was
350 underreported in comparison to 30.4% of fruits. Our results suggest separating fruits
351 and vegetables consumption in dietary surveys.
352
353 The strengths of our study include its originality in using the wearable cameras to
354 enhance children's dietary recall. The camera-assisted method yielded richer objective
355 information on eating environment and eating behaviours, such as the duration of
356 food consumption, the behaviour of watching electric-screen while eating, eating with
357 family members or friends, in comparison to the self-reported questionnaire data.
358 Moreover, our study used the multiple days' dietary assessment method to enhance
359 the reliability and validity of results, while some studies only conducted a one-day
360 dietary assessment [32].
361
362 Limitations of this study should be acknowledged. First, this study was limited to a
363 sample of primary school students at Grade 4. This was due to the consideration that
364 the children at Grade 4 had better understanding capacity compared with those at
365 lower grades, and less study burden than those at higher grades, and thus promote
366 better compliance with the study procedures. Further studies on its use in other ages

are suggested. Second, the 'weighed food intake' or 'doubly labelled water method' were not used as reference methods in this study, so that we were unable to determine the differences between camera-assisted dietary recalls results and true food intake. Third, the battery life for the wearable cameras was not enough for a whole day. The investigator had invested much time to help the students to change camera twice per day. Techniques to prolong the battery life of wearable cameras is urgently needed. Finally, the reliability of our photo annotation was limited by having only one coder. Owing to the restriction of manpower and funding, involving two coders had not been possible in our study. However, after referring to a previous study [16], the investigator performed a re-coding of photos of 10% randomly selected participants, and obtained appropriate consistencies.

## 5. Conclusions

The study provides evidence of the feasibility and acceptability of the use of wearable cameras to assess children's dietary intakes in China. The wearable camera improved the accuracy of children's 24-hour dietary recall by reducing underreported and misreported foods, in particular in the snacking occasions.

## Declarations of interest

None.

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508 **Table 1. Characteristics of the participants.**

| | All participants (N=52) | Healthy (N=26) | Obese (N=26) | $\chi^2$ or t | *P* value |
|---|---|---|---|---|---|
| | Mean± SD or N (%) | | | | |
| Age (years) | 9.8±0.4 | 9.8±0.4 | 9.8±0.5 | 0.29 | 0.774 |
| Sex | | | | | |
| Male | 26 (50) | 13 (50) | 13 (50) | | |
| Female | 26 (50) | 13 (50) | 13 (50) | | |
| Family socioeconomic status | | | | 8.67 | **0.005** |
| Upper | 25 (49) | 18 (72) | 7 (28) | | |
| Lower | 26 (51) | 8 (31) | 18 (69) | | |
| Children's BMI (kg/m$^2$) | 20.8±4.7 | 16.5±1.5 | 25.1±2.0 | -17.95 | **<0.001** |
| Father's BMI (kg/m$^2$) | 25.4±3.2 | 24.9±2.1 | 26.0±4.0 | -1.23 | 0.229 |
| Mother's BMI (kg/m$^2$) | 24.0±3.4 | 22.3±2.4 | 25.7±3.5 | -4.03 | **<0.001** |

509 SD, standard deviation

510 **Table 2. The accuracy of the 3-day 24-hour dietary recalls (DR)[$].**

| | Number of food items N (%) | | | $\chi^2$ | *P* value |
|---|---|---|---|---|---|
| | Correctly reported (n=1869) | Underreported (n=160) | Misreported (n=11) | | |
| Sex | | | | 5.32 | 0.070 |
| Male | 883 (93) | 63 (7) | 3 (0) | | |
| Female | 986 (90) | 97 (9) | 8 (1) | | |
| Weight status | | | | 0.83 | 0.660 |
| Healthy weight | 980 (91) | 89 (8) | 5 (1) | | |
| Obese | 889 (92) | 71 (7) | 6 (1) | | |
| Eating occasions | | | | 394.60 | **<0.001** |
| Breakfast | 423 (94) | 24 (5) | 3 (1) | | |
| Lunch | 726 (97) | 18 (2) | 4 (1) | | |
| Dinner | 573 (96) | 21 (4) | 4 (1) | | |
| Snacking | 147 (60) | 97 (40) | 0 (0) | | |
| Dining locations | | | | 63.75 | **<0.001** |
| Home | 1158 (90) | 128 (10) | 6 (1) | | |
| School | 574 (98) | 10 (2) | 3 (1) | | |
| Restaurant | 101 (91) | 9 (8) | 1 (1) | | |
| Others (*e.g.* on the move to somewhere) | 36 (72) | 13 (26) | 1 (2) | | |
| Food categories | | | | 259.06 | **<0.001** |
| Cereals and tubers | 565 (96) | 11 (2) | 10 (2) | | |
| Vegetables | 331 (96) | 14 (4) | 0 (0) | | |
| Fruits | 78 (70) | 34 (30) | 0 (0) | | |
| Animal foods | 511 (95) | 25 (5) | 0 (0) | | |
| Soya nuts | 71 (95) | 4 (5) | 0 (0) | | |
| Snacks and desserts | 184 (84) | 34 (16) | 1 (0) | | |
| Beverages | 53 (63) | 31 (37) | 0 (0) | | |
| Others (*e.g.* condiments) | 76 (92) | 7 (8) | 0 (0) | | |

511 [$]Results from the camera-assisted 24-hour dietary recalls were used as references.

**Table 3. Daily dietary intakes obtained by dietary recalls with and without camera assistance (N=52).**

| | DR (Mean±SD) | Camera-assisted DR (Mean±SD) | Difference (Mean±SD) | Percentage (%) of difference | t | $P_1$ | r | $P_2$ |
|---|---|---|---|---|---|---|---|---|
| Energy (kcal) | 1804±539 | 1954±530 | -150±182 | 8 | -5.95 | **<0.001** | 0.94 | **<0.001** |
| Carbohydrate (g) | 246.9±74.2 | 271.1±74.9 | -24.2±29.6 | 9 | -5.91 | **<0.001** | 0.92 | **<0.001** |
| Fat (g) | 58.9±24.6 | 62.6±24.4 | -3.7±6.1 | 6 | -4.39 | **<0.001** | 0.97 | **<0.001** |
| Protein (g) | 77.8±31.8 | 83.7±32.7 | -5.9±12.5 | 7 | -3.40 | **0.001** | 0.93 | **<0.001** |
| Dietary fiber (g) | 9.9±6.6 | 11.9±8.1 | -1.9±5.5 | 16 | -2.53 | **0.015** | 0.73 | **<0.001** |
| Vitamin A (μgRE) | 433.2±321.1 | 548.5±450.0 | -115.3±327.1 | 21 | -2.54 | **0.014** | 0.69 | **<0.001** |
| Thiamin (mg) | 0.9±0.4 | 0.9±0.4 | -0.1±0.1 | 11 | -5.21 | **<0.001** | 0.98 | **<0.001** |
| Riboflavin (mg) | 0.9±0.4 | 1.0±0.4 | -0.1±0.1 | 10 | -4.44 | **<0.001** | 0.92 | **<0.001** |
| Vitamin C (mg) | 61.0±38.5 | 74.6±45.9 | -13.6±26.2 | 18 | -3.74 | **<0.001** | 0.82 | **<0.001** |
| Calcium (mg) | 422.3±240.8 | 496.5±282.9 | -74.2±136.1 | 15 | -3.93 | **<0.001** | 0.88 | **<0.001** |
| Potassium (mg) | 1847.3±1001.2 | 2118.9±1120.7 | -271.6±587.0 | 13 | -3.34 | **0.002** | 0.85 | **<0.001** |
| Sodium (mg) | 1287.4±653.5 | 1392.8±669.9 | -105.4±217.3 | 8 | -3.50 | **0.001** | 0.95 | **<0.001** |
| Magnesium (mg) | 248.9±112.5 | 280.5±126.8 | -31.6±69.9 | 11 | -3.26 | **0.002** | 0.84 | **<0.001** |
| Iron (mg) | 20.7±13.4 | 23.0±14.0 | -2.3±5.4 | 10 | -3.07 | **0.003** | 0.92 | **<0.001** |
| Zinc (mg) | 11.3±4.5 | 12.1±4.5 | -0.8±1.6 | 7 | -3.64 | **<0.001** | 0.93 | **<0.001** |

DR, no-camera-assisted 24-hour dietary recalls;
Difference, DR-Camera-assisted DR;
Percentage (%) of difference, Difference/Camera-assisted DR*100%
r, correlations between results from DR and Camera-assisted DR;
$P_1$, P value for the differences between results from DR and Camera-assisted DR, independent sample T-test;
$P_2$, P value for the correlations between results from Camera-assisted DR and DR.

521 **Table 4. Children's satisfaction to the wearable cameras (N=52).**

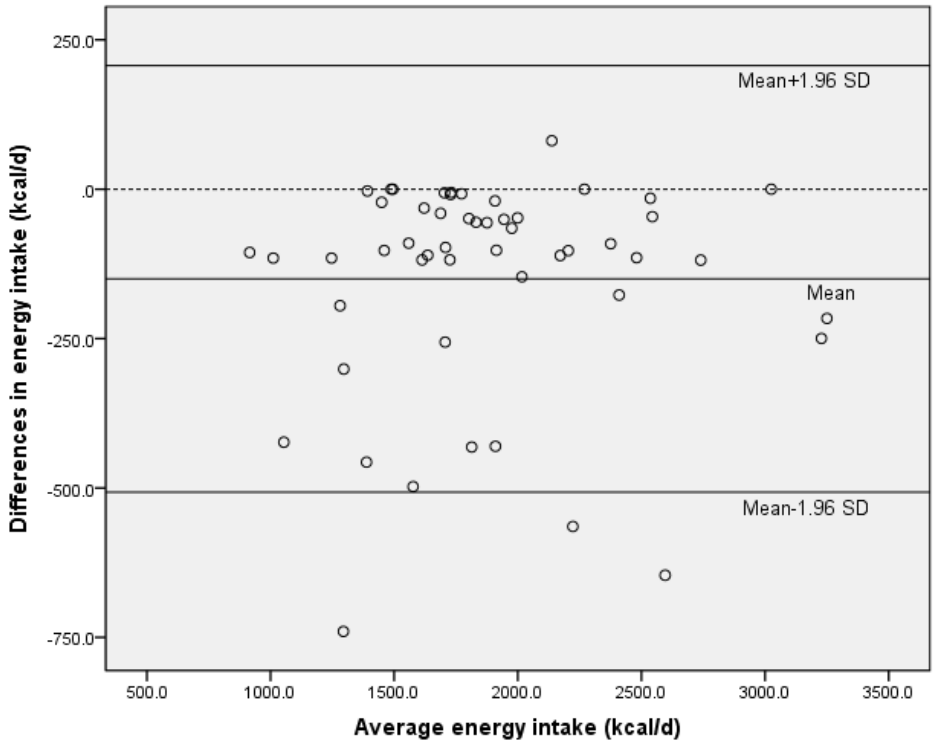
| Camera feature | Very unsatisfied | Unsatisfied | Neutral | Satisfied | Very satisfied | Satisfaction score |
|---|---|---|---|---|---|---|
| | N (%) | N (%) | N (%) | N (%) | N (%) | Median (IQR) |
| Weight | 0 (0) | 0 (0) | 3 (6) | 4 (8) | 45 (87) | 5.0 (5.0-5.0) |
| Size | 0 (0) | 0 (0) | 1 (2) | 3 (6) | 48 (92) | 5.0 (5.0-5.0) |
| Appearance | 0 (0) | 0 (0) | 4 (8) | 5 (10) | 43 (83) | 5.0 (5.0-5.0) |
| Degree of comfort | 0 (0) | 1 (1.9) | 3 (6) | 15 (29) | 33 (64) | 5.0 (4.0-5.0) |
| Manner of wearing | 0 (0) | 0 (0) | 4 (8) | 7 (14) | 41 (79) | 5.0 (5.0-5.0) |
| Speed of battery charging | 0 (0) | 1 (1.9) | 0 (0) | 6 (12) | 45 (87) | 5.0 (5.0-5.0) |

522 IQR: interquartile range

523 **Table 5. Dietary behaviours of healthy and obese children, measured by**
524 **camera-assisted dietary recalls (N=52).**

| | Healthy (N=26) (Mean±SD) | Obese (N=26) (Mean±SD) |
|---|---|---|
| Average mealtime duration (minute) | 13.0±3.8 | 13.7±5.3 |
| Average eating rate (g/min) | 28.7±10.0 | 29.0±11.8 |
| Number of days eating outside home in the study week | 1.0±1.3 | 1.0±1.0 |
| Number of days eating in the western fast food restaurants in the study week | 0.4±0.9 | 0.1±0.3 |
| Number of days having breakfast in the study week | 6.4±1.2 | 6.3±1.2 |
| The proportion of watching electric screen while eating | 19.9±22.1 | 25.1±22.5 |
| The proportion of dining accompanied by others | 89.2±13.5 | 78.8±17.8 |

525 **Figure 1. Agreement of two methods (dietary recalls with and without camera**
526 **assistance) in measuring energy, carbohydrate, protein and fat intakes, by**
527 **Bland-Altman limits of agreement plots**

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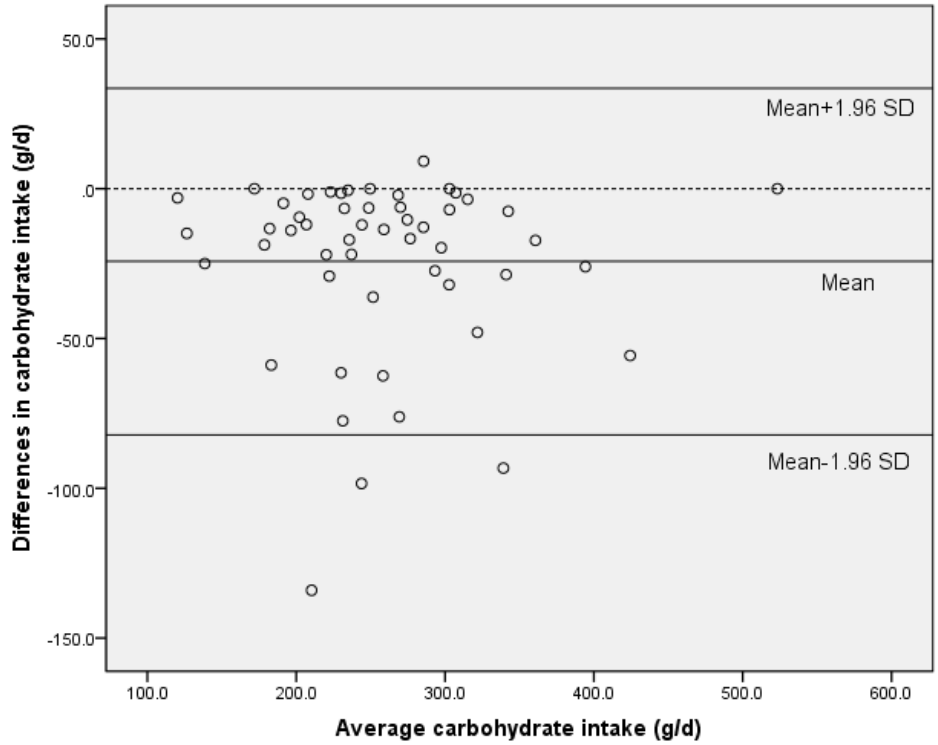


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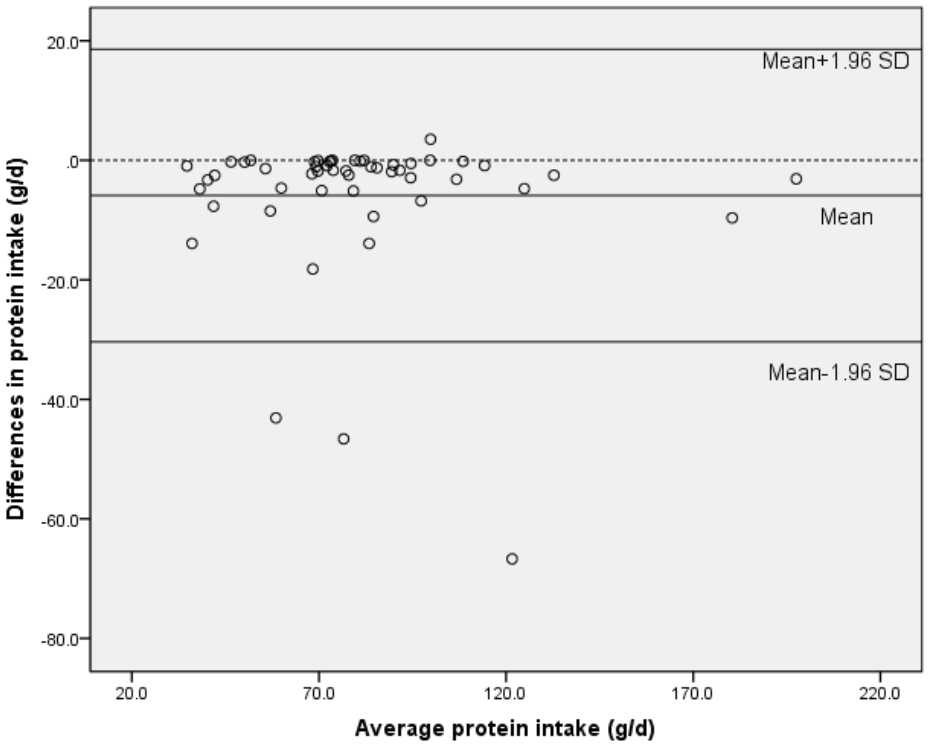
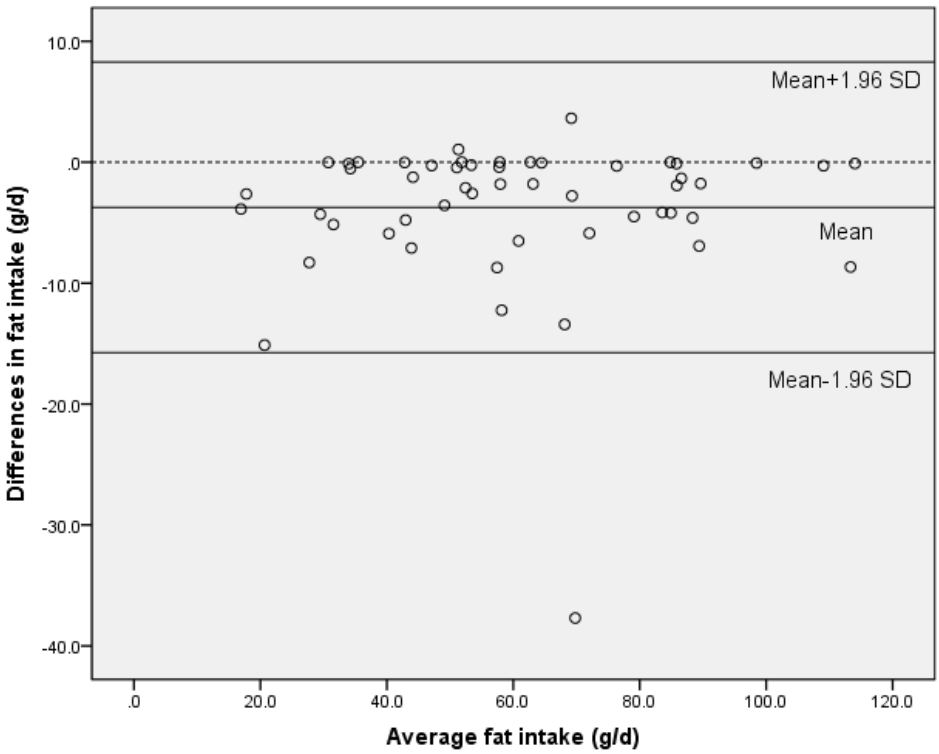

Mean+1.96 SD
Mean
Mean-1.96 SD
Differences in protein intake (g/d)
Average protein intake (g/d)
20.0
.0
-20.0
-40.0
-60.0
-80.0
20.0
70.0
120.0
170.0
220.0

530


Mean+1.96 SD
Mean
Mean-1.96 SD
Differences in fat intake (g/d)
Average fat intake (g/d)
10.0
.0
-10.0
-20.0
-30.0
-40.0
.0
20.0
40.0
60.0
80.0
100.0
120.0

531